# CALIFORNIA HIGH-SPEED TRAIN

# DRAFT

# STATEWIDE ENERGY
# TECHNICAL EVALUATION

June 2003

*Prepared for:*

California High-Speed Rail Authority

U.S. Department of Transportation
Federal Railroad Administration

CALIFORNIA HIGH SPEED RAIL AUTHORITY

U.S. Department
of Transportation
**Federal
Railroad
Administration**

# CALIFORNIA HIGH-SPEED TRAIN PROGRAM EIR/EIS

# Statewide

# Energy

# Technical Evaluation

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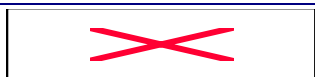Phone:  (949) 260-1080

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# ACRONYMS

| | |
|---|---|
| AB | ASSEMBLY BILL |
| ADP | AIRPORT DEVELOPMENT PROGRAM |
| AUTHORITY | CALIFORNIA HIGH-SPEED RAIL AUTHORITY |
| BCF | BILLION CUBIC FEET |
| Btu | British Thermal Unit |
| Cal-ISO | CALIFORNIA-INDEPENDENT SERVICE OPERATOR |
| Caltrans | CALIFORNIA DEPARTMENT OF TRANSPORTATION |
| CEC | CALIFORNIA ENERGY COMMISSION |
| CEQA | CALIFORNIA ENVIRONMENTAL QUALITY ACT |
| COG | COUNCIL OF GOVERNMENTS |
| CPUC | CALIFORNIA PUBLIC UTILITIES COMMISSION |
| EIR | ENVIRONMENTAL IMPACT REPORT |
| EIS | ENVIRONMENTAL IMPACT STATEMENT |
| EMU | ELECTRICAL MECHANICAL UNIT |
| EPA | ENVIRONMENTAL PROTECTION AGENCY |
| FAA | FEDERAL AVIATION ADMINISTRATION |
| FERC | FEDERAL ENERGY REGULATORY COMMISSION |
| FHWA | FEDERAL HIGHWAY ADMINISTRATION |
| FRA | FEDERAL RAILROAD ADMINISTRATION |
| FTA | FEDERAL TRANSIT ADMINISTRATION |
| GW | GIGAWATT |
| GWH | GIGAWATT-HOURS |
| HST | HIGH-SPEED TRAIN |
| ISTEA | INTERMODAL SURFACE TRANSPORTATION EFFICIENCY ACT |
| IOU | INVESTOR-OWNED UTILITY |
| KW | KILOWATT |
| KWH | KILOWATT-HOURS |
| MPH | MILES PER-HOUR |
| MPO | METROPOLITAN PLANNING ORGANIZATION |
| MW | MEGAWATT |
| MWH | MEGAWATT-HOURS |
| PG&E | PACIFIC GAS & ELECTRIC |
| PX | POWER EXCHANGE |
| RTP | REGIONAL TRANSPORTATION PLAN |
| SCE | SOUTHERN CALIFORNIA EDISON |
| SDG&E | SAN DIEGO GAS & ELECTRIC |
| STIP | STATE TRANSPORTATION IMPROVEMENT PROGRAM |
| SUV | SPORT UTILITY VEHICLE |
| TCF | TRILLION CUBIC FEET |
| TEA21 | TRANSPORTATION EQUITY ACT FOR THE 21ST CENTURY |
| UDC | UTILITY DISTRIBUTION COMPANY |
| USACE | U.S. ARMY CORPS OF ENGINEERS |
| USFWS | U.S. FISH AND WILDLIFE SERVICE |
| VHS | VERY HIGH-SPEED |
| VMT | VEHICLE MILES TRAVELED |
| W | WATT |
| WAPA | WESTERN AREA POWER ADMINISTRATION |

# 1.0 INTRODUCTION

## 1.1 KEY OPERATIONAL AND CONSTRUCTION ENERGY IMPACTS AND MITIGATION STRATEGIES

Table 1.1-1 summarizes the statewide operational and construction-related impacts.  Important findings are discussed below.
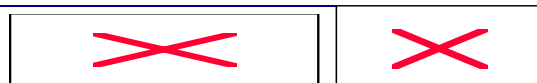
**Operational**

A substantial beneficial impact to the overall transportation-related energy use in the state would result with the implementation of the HST Alternatives due mostly to a decrease in cross-modal VMT.  If any, the Modal Alternative would result in a substantially smaller beneficial impact, as compared to the No-Project Alternative, as a result of improvements on No-Project traffic flow, which would, in turn improve energy efficiency of the automobile fleet.

Impacts to the peak demand on the state's electricity grid system under the HST Alternative would be potentially significant if the resource capacity were not equipped to handle the additional load.  The situation cannot be fully assessed presently because resource additions have a two- to three-year planning horizon.  However, notwithstanding the short resource planning horizon, current and planned power plant construction in the state electricity market would boost total statewide supply capacity to about 64,669 MW in 2008, which, coupled with an anticipated 59,459-MW peak-demand statewide, would produce a surplus of 5,210 MW (CEC 2002a).  If the system were to become operational in 2008, the additional load placed on the system by the HST Alternative would be about 10% of the state's anticipated electricity surplus. Prediction horizons for demand estimates are longer than for capacity additions.  Comparing the additional 480-megawatt load placed on statewide electricity generating resources by the HST Alternative would represent approximately 0.7% of the CEC-predicted 2012 statewide electricity demand of 64,845 MW.  Projecting the demand horizon to the study year of 2020, the HST Alternative-generated load would represent 0.6% of an estimated 77,000 MW statewide demand[1].  As the HST system would be built and begin operations over a ten-year period, state electricity generation and transmission industry and planners would have leeway to anticipate and respond to the effects of the both the HST Alternative on generating and transmitting resources.

**Construction**

Construction of the Modal (both highway and aviation components) and HST Alternatives would result in one-time, non-recoverable energy costs.  Energy used for the construction of the Modal System Alternative would be paid back by operational energy savings much more slowly than the HST System Alternative, if it were paid back at all.  A construction management plan would be required as mitigation under the Modal and HST Alternatives to minimize construction-related impacts to energy resources.  The HST Alternative would allow substantial energy savings with regard to vehicle manufacture over both the No-Project and Modal Alternatives.

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[1] Calculation based on CEC demand projections from 2002 to 2012 for normal temperature years, published in *2002 – 2012 Electricity Outllook* (CEC 2002a).  Projection to 2020 assumes an average annual growth rate of about 2.0% with a range from between 1.5% and 3.9%.  This projection is for comparison purposes only.

**Table 1.1-1**
**Statewide Operational and Construction Impacts**

| | Operational | | Construction |
|---|---|---|---|
| | **Overall Energy** | **Electricity Usage** | |
| **No-Project Alternative** | *Potentially significant:*<br><br>Congestion levels would increase energy use. The amount is not quantifiable at current level of planning. With an example of a 5% increase in the automobile energy consumption factor, total energy use would increase from 24.2 million to 25.3 million barrels of oil | *Less-than-significant:*<br><br>Electricity generation and transmission is anticipated to keep pace with demand through 2008 (CEC 2003). If the trend continues, future build-year electricity surplus would be ample. | *Less-than-significant:*<br><br>Construction of No-Project Alternative would be guided by mitigation measures identified in specific environmental documents. |
| **Modal Alternative** | *No Impact:*<br><br>Modal Alternative would increase energy use by about 0.2 million barrels of oil over the un-congested No-Project scenario, or about 0.2% if similar levels of congestion area assumed. With congested No-Project automobile energy consumption factor, a net energy savings of 0.7 million barrels of oil would be indicated. | *Less-than-significant:*<br><br>Electricity generation and transmission is anticipated to keep pace with demand through 2008 (CEC 2003). Small increases in electricity demand by airport facilities in the build-year would be expected. If the current trend continues past 2008, future build-year electricity surplus would be ample. | *Potentially significant:*<br><br>Scope and scale of proposed improvements render construction of Modal Alternative potentially significant. Construction energy would be paid back in 5 years with the un-congested No-Project and in 4 years with a congested No-Project automobile energy consumption factor. Automobile's lack of durability would make Modal Alternative vehicle manufacturing-related energy consumption potentially significant. |
| **HST Alternative** | *Beneficial:*<br><br>HST Alternative would decrease energy use by about 5.3 million barrels of oil over the un-congested No-Project scenario, or about 22%. With congested No-Project automobile energy consumption factor, a net energy savings of 6.2 million barrels of oil would be indicated. | *Less-than-significant:*<br><br>Additional HST-related peak-period load of the order of 480 MW would represent 0.8% of the estimated 2008 statewide demand and 0.6 % of projected 2020 statewide electricity demand. | *Potentially significant:*<br><br>Scope and scale of proposed improvements render construction of HST Alternative potentially significant. Construction energy would not be paid back with the un-congested No-Project. Payback period would be 55 years with a congested No-Project automobile energy consumption factor. The HST Alternative vehicles would be relatively durable, saving on vehicle manufacturing-related energy consumption. |

# 2.0 AFFECTED ENVIRONMENT

## 2.1 STUDY AREA

The area potentially affected by the alternatives are the regions comprising six of the fifteen California air basins, including Sacramento, San Francisco Bay, San Joaquin Valley, Mojave Desert, South Coast, and San Diego. The air basins were used to define the area of analysis because the majority of intercity trips taken in California occur within them. Nearby air basins may also be affected by the project alternatives, but any impact is expected to be minimal compared to the basins that physically contain the project alternatives.

## Z2.2 REGULATORY SETTING

### 2.2.1 FEDERAL REGULATIONS

#### 2.2.1.1 Federal Energy Regulatory Commission

The Federal Energy Regulatory Commission (FERC) is an independent agency that regulates the interstate transmission of natural gas, oil, and electricity. FERC also regulates natural gas and hydropower projects. As part of that responsibility, FERC regulates the transmission and sale of natural gas for resale in interstate commerce, the transmission of oil by pipeline in interstate commerce, and regulates the transmission and wholesale sales of electricity in interstate commerce. FERC also licenses and inspects private, municipal, and state hydroelectric projects, approves the sighting of and abandonment of interstate natural gas facilities, including pipelines, storage and liquefied natural gas, oversees environmental matters related to natural gas and hydroelectricity projects and major electricity policy initiatives, and administers accounting and financial reporting regulations and conduct of regulated companies.

#### 2.2.1.2 Corporate Average Fuel Economy Standards

Corporate Average Fuel Economy (CAFE) standards are federal regulations that are set to reduce energy consumed by on-road motor vehicles. The standards specify minimum fuel consumption efficiency standards for new automobiles sold in the United States. The current standard for passenger cars is 27.5 miles per gallon (mpg). The 1998 standard for light trucks was 20.7 mpg (Competitive Enterprise Institute 1996). In April 2002, the National Highway Traffic Safety Administration, part of the US DOT, issued a final rule for CAFE standards for model-year 2004 light trucks that codified a standard of 20.7 mpg; this level is now in effect (U.S. Department of Transportation 2002a).

#### 2.2.1.3 Transportation Equity Act for the 21st Century

The Transportation Equity Act for the 21$^{st}$ Century (TEA21), passed in 1998 builds on the initiatives established in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), which was the prior authorizing legislation for surface transportation. The ISTEA identified planning factors for use by Metropolitan Planning Organizations (MPOs) in developing transportation plans and programs. Under the ISTEA, MPOs are required to "[p]rotect and enhance the environment, promote energy conservation, and improve quality of life" and are required to consider the consistency of transportation planning with federal, state, and local energy goals (U.S. Department of Transportation 2002b).

### 2.2.2 STATE REGULATIONS

#### 2.2.2.1 California Code of Regulations, Title 24, Part 6, Energy Efficiency Standards

Title 24, Part 6 of the California Code of Regulations, Energy Efficiency Standards promotes efficient energy use in new buildings constructed in California. The standards regulate energy consumed for

heating, cooling, ventilation, water heating, and lighting. The standards are enforced through the local building permit process.

### 2.2.2.2 California Assembly Bill 1X

California Assembly Bill 1X (AB 1X), February 1, 2001, authorized the California Department of Water Resources to purchase electricity under long-term contracts to re-sell to two utilities: PG&E and SCE. This law was passed because, as a result of financial constraints, the two utilities were unable to obtain long-term power contracts with power generators. AB 1X makes the state government an active participant in California's power industry (CEC 2002a).

## 2.3 STATE SETTING

### 2.3.1 Energy Demand, Capacity, and Supply

California is the 10th-largest worldwide energy consumer and is ranked 2nd in the U.S. behind Texas. Of the overall energy consumed in the state, the transportation sector represents the largest proportion, at 46%, followed by the industrial sector, 31%; residential sector, 13%; and commercial sector, 10%. Petroleum satisfies 54% of California's energy demand; natural gas, 33%; and electricity, 13% (coal fuel in California accounts for less than 1%). Electric power and natural gas in California are generally consumed by stationary users, whereas petroleum consumption is generally accounted for by transportation related energy use (California Energy Commission [CEC] 2000). A description of the energy resources and market conditions that could be affected by the alternatives is described below.

### 2.3.2 Petroleum

Demand for transportation services (and, therefore, petroleum/gasoline consumption) in California mirrors the growth of the state's population and economic output. Historical trends coupled with current population and economic growth projections predict that transportation sector use of gasoline and diesel fuels will increase by approximately 40% over the next 20 years, gasoline demand is projected to increase from 13.9 billion gallons in 1999 to 19.9 billion gallons by 2020 and diesel from 2.4 billion gallons to 4.8 billion gallons over the same period. The California Energy Commission (CEC) projects that in-state oil refining capacity will lag behind this forecasted growth if major changes to the in-state oil refining industry are not made, which could result in sudden price increases for both gasoline and diesel fuels over sustained time periods (CEC 2000). Foreign petroleum imports account for approximately 29% of the state's petroleum supply, a fraction that is expected to increase as in-state and Alaskan oil production declines (CEC 2002c).

The combination of strong growth in gasoline demand, recently phased-out fuel additive Methyl Tertiary Butyl Ether (MTBE), significantly expanded use of ethanol necessitated by the federal minimum oxygen requirement, and transition to Phase 3 RFG (Reformulated Gasoline) could affect the balance between supply and demand of transportation fuels in California and impair the ability of refiners to consistently supply volumes of gasoline to meet California demand. MTBE is a gasoline-blending component that was used in gasoline oxygenate to help control carbon monoxide emissions before it was completely phased-out in California-sold gasoline as of December 31, 2002, per a Gubernatorial directive. Phase 3 RFG prohibits use of MTBE and directs use of only ethanol as oxygenate. Revisions of state and federal regulations to further tighten specifications for diesel fuel are underway to reduce environmental impacts. Together, these efforts to improve the environmental performance of petroleum fuels pose challenges to producing fuel volumes required to satisfy California's growing transportation-related fuel consumption. According to CEC staff, it would be difficult for the state to rely solely on petroleum-based fuels in the future, if it desires a stable transportation fuel market. (CEC 2000)

### 2.3.3 Electricity

Electric energy is given special consideration in this analysis, as compared to other sources of power, because of the recent events concerning California's electricity markets and the projected reliance of high-speed train service on electric energy to power its operations.

### 2.3.3.1 Existing State Electricity Supply And Demand

In-state electricity generation, which accounted for 85% of the 2001 total, is fueled by natural gas (42.7%), nuclear (12.6%), coal[2] (10.4%), large hydro-electric resources (8.0%), petroleum (0.5%), and renewable resources, including wind, solar, and geothermal, (10.5%). Electricity imports in 2001 were 15% of total production. Imports from the Pacific Northwest accounted for 2.6% and 12.8% came from the Southwest. (California Energy Commission. 2003a. California's Major Sources of Energy. Available: www.energy.ca.gov/htm/energysources.html. Accessed: June 14, 2003. Accessed by: Garrick Jones. Last Updated: March 21, 2003).

According to the CEC, total statewide electricity consumption grew from 166,979 gigawatt-hours (GWh) in 1980 to 228,038 GWh in 1990, an annual growth rate of 3.2 percent[3]. The 1990's saw a slowdown in demand growth as a result of the recession that lasted through the early- and mid-decade. The statewide electricity consumption in 1998 was 244,599 GWh, reflecting an annual growth rate of 0.9 percent for the period from 1990 to 1998. (CEC 2002a)  In 2001, statewide consumption was about 250,000 GWh (CEC 2002b).

Peak electricity demand, expressed in megawatts (MW), measures the largest electric power requirement during a specified period of time, usually integrated over one hour. One MW is enough power to meet the electricity needs of 1,000 typical California homes (CEC 2003b). For comparison one GW would be enough power for 1,000,000 typical homes. Peak demand is important in evaluating system reliability, determining congestion points on the electrical grid, and identifying potential areas where additional transmission, distribution, and generation facilities are needed. California's peak demand typically occurs between the hours of 3 and 5 p.m. on an August day. High temperatures lead to increased air conditioning use, which, in combination with industrial loads, commercial lighting and office equipment, and residential refrigeration, comprise the major contributors of electricity consumption in the peak period of electricity demand in California (CEC 2000). In 2003, according to the CEC, peak electricity demand for California is predicted to be about 52,150 MW[4]. Peak generating capacity for the state was about 59,696 MW[5] (CEC 2003c). The California Independent State Operator (Cal-ISO) controls the electrical grid that distributes about 82% of the electricity consumed in the state. A potential HST system would likely draw most, though not necessarily all, of its electricity from the Cal-ISO-controlled grid, illustrated in Figure 2.3-1.

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[2] Intermontane and Mohave coal plants are considered in-state, since they are in California control areas.

[3] Electric energy is measured in watts (W); 1,000 watts is a kilowatt (kW), 1,000 kilowatts is a megawatt (MW), and 1,000 megawatts is a gigawatt (GW). Electric consumption over time is measured in kilowatt-hours (kWh), megawatt-hours (MWh), and gigawatt-hours (GWh).

[4] Does not Include 7% operating reserve.

[5] Includes net dependable generating additions of about 3,600 MW, as of July 2003, and forced and planned outages of 3,750 MW. Does not include spot market imports of 3,721 MW.
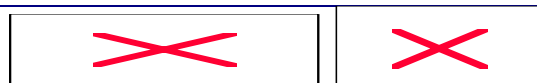
**FIGURE 2.3-1:  Cal-ISO–Controlled Grid**



Source:  Cal-ISO 2002a

### 2.3.3.2 Electricity Supply And Demand Outlook

In 1998 the state began a market restructuring and divestiture.  Prior to the enactment of Assembly Bill 1890 (AB 1890), utility companies were vertically integrated—they owned and operated the three major utility functions (electrical generation, transmission, and distribution).  After enactment of AB 1890 separated the three major utility functions into individually-owned and –operated entities.  California's Investor-Owned Utilities (IOU) (Pacific Gas & Electric [PG&E], Southern California Edison [SCE], and San Diego Gas & Electric [SDG&E]) became local "Utility Distribution Companies" (UDCs), having primary responsibility for distribution services only.  (CPUC 1998)

Passage of AB 1890 created a vertically disaggregated wholesale power grid, which is a network of long-distance, high-voltage transmission lines, and substations carrying bulk electricity to local utilities for distribution to their customers.  Cal-ISO, a not-for-profit public benefit corporation that is regulated by the Federal Energy Regulatory Commission (FERC), was created to act as the grid's impartial operator, providing for open and nondiscriminatory transmission service and ensuring safe and reliable grid operations.  (Cal-ISO 2002c). The extent of its mandated purview is equivalent to the boundaries of the three IOUs and accounts for approximately 82% of the state's electrical deliveries (Cal-ISO 2003).  The IOUs are required by AB 1890 to sell all their generated power into and purchase all their electricity from a newly created Power Exchange (PX), which was set up to provide the market for electric power sales and purchases and allow all power producers to compete on common ground, using transparent rules. The PX schedules its deliveries through Cal-ISO (CPUC 1998).

Studies have been conducted by the CEC to predict the short- and long-term outlooks for electricity supply and demand balance.  According to its 2003 Staff Report titled, *California's Electricity Supply and*

*Demand Balance Over the Next Five Years*, the CEC believes that the near-term outlook for supply adequacy is promising, estimating a 16% Operating Margin[6] for summer 2003 (assuming a 1-in-2 year peak temperature condition) in the Cal-ISO-controlled grid where supply is expected to outpace demand approximately 6,000 MW[7] (CEC 2003c). According to CEC staff, a statewide Planning Reserve Margin[8] of 8.8% is projected as far out as August 2008, when statewide supply capacity is anticipated to be 64,669 MW outpacing a statewide projected demand of 59,459 MW[9] (CEC 2003c). The apparent decline in reserve margins is due to the fact that the planning horizon for electric power resource additions is usually only 2 to 3 years out and is not necessarily an indicator of generating capacity following a downward trend. This short planning horizon interjects uncertainty into the assessment of supply and reserve margin in 2020, the study year. However, the state has added substantial generating capacity in the last 2 years and will continue to add capacity. Between 2000 and February 2003, California has licensed and added 18 new power plants, which have contributed 4,980 MW to the statewide generating capacity. From February to August of 2003 power plants representing 3,106 MW of generating capacity are anticipated to come on line (CEC 2003d). Statewide demand in 2012 would most likely be around 64,845, assuming normal summer temperatures (CEC 2002b). Using the growth trend that fits the demand predictions by the CEC staff through 2012, published in the *2002 –2012 Electricity Outlook*, demand for electricity in 2020 can be estimated to be on the order of 77,000 MW[10]. Cal-ISO estimates that net generation capacity additions of 1,000 to 1,500 MW/year will be necessary to maintain current operating margins (Cal-ISO 2002b).

### 2.3.3.3 Electricity Transmission Capacity Outlook

Electricity transmission capacity refers to the maximum amount of power that can be carried from the generating source to the utility provider and is a key component in the electrical power delivery system. In the years since the start of the electricity crisis, the transmission capabilities of some portions of the state's electrical grid have occasionally not been adequate to transmit electricity at a rate that would satisfy the quantities of electricity that have, and are being demanded. This phenomenon is known as transmission bottlenecks. An example of one such current bottleneck occurs through what is known as Path 15, a major transmission line between northern and southern California through the Central Valley. According to the Western Area Power Administration (WAPA), PG&E plans to increase the rating of Path 15 from 3,900 MW to 5,400 MW, which is expected to be completed by 2004. Improvements to other transmission paths are also planned. (WAPA 2002)

### 2.3.4 Natural Gas

California is the 2nd largest consumer of natural gas in the nation, having consumed more than 5.5 billion cubic feet (Bcf) per day in 1997. Approximately 33% of this total daily consumption was for electricity generation, 25% for residential consumption, followed by industrial, resource extraction, and commercial sectors. The CEC's gas demand forecast projects continued growth at 1.3 percent per year, with volumes exceeding 7 Bcf per day by 2019. Natural gas supplies to California will remain plentiful for the next several decades. The total resource base (gas recoverable with today's technology) for the lower 48 states is estimated to be about 975 trillion cubic feet (Tcf), enough to continue current production levels for more than 50 years. Technology enhancements will continue to enlarge this resource base; however, production capacity increases remain less certain (CEC 1999). Despite this concern, production in the

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[6] The percentage by which demand outpaces supply; includes a 7% operating reserve in calculation. (CEC 2003b)

[7] Including Operating Reserve of 5,707 MW.

[8] Differs from Operating Margin by not including the 7% operating reserve in calculation and does not account for forced outages or include spot market purchases. It is used in extended planning horizons. (CEC 2003c)

[9] Demand projection assumes a normal summer. A hot summer increases projected demand to 62,914 MW, which corresponds to a 3.0% Planning Reserve Margin.

[10] Calculation based on CEC demand projections from 2002 to 2012 for normal temperature years, published in *2002 – 2012 Electricity Outllook* (CEC 2002b). Projection to 2020 assumes an average annual growth rate of about 2.0% with a range from between 1.5% and 3.9%. This projection is for comparison purposes only.

continental U.S. is expected to increase from 19.36 Tcf in 2001 base year to 32.14 Tcf in 2020 (United States Department of Energy, Energy Information Administration. 2003. Annual Energy Outlook 2003 with Projections to 2025. Available: www.eia.doe.gov/oiaf/tbl22.html. Last modified: July 21st.) As of 2001, in-state natural gas production accounted for 15% of total consumption. Out-of-state production includes the Southwest (50%), the Rocky Mountains (10%), and Canada (25%) (California Energy Commission, 2003a).

### 2.3.4.1 The Relationship between Natural Gas and Electricity Resources in California

Because of the large role that natural gas plays in electricity production throughout the Southwest and in particular in California, where natural gas fueled 42.7% of electricity production in 2001 (a percentage which is likely to grow in the future as the trend toward building natural gas power plants continues), natural gas price elevations have direct effect on the price of electricity. During the spot market price spike of February of 2003, regional electricity prices rose 45% between early February and February 24, 2003 and an additional 150% between February 24 and February 26, 2003. Since late February natural gas prices have steadily fallen and electricity prices have followed suit. (CEC/CPUC. 2003. *Natural Gas Market Prices.* Sacramento. March.)

Notwithstanding the relationship between conditions in the natural gas market and electricity prices, the functioning of the natural gas market, as well as the consequences of price changes in the natural gas market, are fundamentally different than the electricity market. Natural gas, unlike electricity, has the property of storability, which gives natural gas an advantage as a commodity over electricity. Because electricity is not storable, a true long-term futures market cannot function, as it does for durable commodities, and rates are determined almost solely by electricity spot markets. The lack of a futures market makes electricity rates susceptible to the affects of extreme swings in supply and demand. Oppositely, the storability of natural gas not only provides the advantages that a fairly well functioning futures market[11] offers with regard to upward pressure that risk puts on prices, but it allows utilities to buy natural gas when prices are low and store it until prices rise. In short, natural gas acts as any other durable commodity in the market place does, including oil. Short-term shortages are mitigated by the above stated mechanisms. Long-term price increases are corrected by increases in production capacity, the expectation of which, in turn, acts to bring prices down. Since the projected national in-the-ground natural gas reserves are expected to last for at least the next 50 years, actual supplies are not considered to be limiting and short- and long-term prices are mostly a function of market conditions, as is any other commodity, including oil. (CEC/CPUC. 2003. *Natural Gas Market Prices.* Sacramento. March.)

### 2.3.4.2 California's Natural Gas Market

Although California's natural gas market is affected by nationwide price conditions, it is insulated from the full magnitude of the price swing amplitudes. Starting in 2000-01, during the last major price elevation, major steps were taken to thwart further damage to the state by nationwide price conditions. The state's natural gas utilities have obtained additional interstate pipeline capacity rights on El Paso Interstate Pipeline in the fall of 2002. This allowed the state to maintain adequate inflow rates (during the recent price spike, pipelines serving California were running at 50-70% capacity, indicating that excess capacity was available, if it had been needed). The trend toward more pipeline capacity is being continued in California by projects such as the Ken River Expansion pipeline project, which became operational on May 1. Utilities have also invested in underground storage capacity that will allow them to dampen the effect of future severe price increases by drawing on stored gas instead of buying high priced open market natural gas, an effective mechanism for controlling annual costs. Indeed, capacity additions were added in 1999 and in 2002 with the construction of Wild Goose Storage (14 Bcf, with the further expansion of 15 Bcf expected in 2004) and Lodi Gas (12 Bcf), respectively.

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[11] The quality of data available to market analysts has been a source of some concern recently, although steps are currently being taken of the national level to remedy this situation.
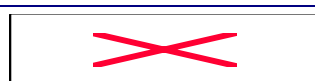
In addition to the above-stated steps that California has taken to insulate itself against future natural gas price increases, California has provided utilities with the flexibility and the tools to manage gas costs by purchasing natural gas supplies under different contract lengths and pricing terms, and from a variety of supply sources. In addition, California is in the process of increasing its supplies of electricity from renewable power sources. In 2002, the Governor signed the Renewable Portfolio Standard (RPS), SB 1078. According to the RPS, 20% of California's electricity needs should be generated by renewable sources by 2017. (Increasing California's renewable supplies will diminish the states heavy dependence on natural gas as a fuel for electric power generation.) (CEC/CPUC. 2003. *Natural Gas Market Prices.* Sacramento. March.)

### 2.3.5 Transportation Energy Consumption

Transportation accounts for a large portion of the California energy budget, with approximately 46% of the state's energy consumption resulting from the transport of goods and people. Between 1997 and 2020, the state is forecasted to grow by about 11 million people, or approximately 30% (Department of Finance 1998). During this same period, intercity travel is projected to grow by almost 40% to almost 215 million trips per year (California High-Speed Rail Authority 2000). Although the average fuel economy of vehicles in the state has improved, the fuel savings achieved are overshadowed by an increase in the number of miles traveled and the marked shift in personal vehicle preference, from the standard automobile toward larger vehicles, like sport utility vehicles (SUVs) and pick-up trucks. Currently, California's 24 million automobiles consume more than 17 billion gallons of petroleum, most of which is consumed in southern California, which makes California the third largest consumer of petroleum fuel in the world. Only the United States as a whole and the former Soviet Union exceed this volume. Because of this dependence on petroleum fuels, events in the international petroleum market can immediately and adversely affect California fuel supply and price (CEC 1999).

Four options exist for intercity travel between the major urban areas of California: automobiles on the interstate highway system and state highways, commercial airlines, conventional passenger trains (Amtrak) on freight and/or commuter rail tracks, and long-distance commercial bus transit. These four modes of intercity travel represent a wide range of service characteristics, such as travel time and frequency. Automobiles and airplanes are the predominant modes of intercity trips greater than 150 miles in length.

The effects of transportation congestion on energy consumption and air emissions can be major. Automobiles are most efficient when operating at steady speeds of 35 to 45 mph, with no stops (Oak Ridge Laboratory 1983, USDOT 1983). Fuel consumption increases by about 30% when average speeds drop from 30 to 20 mph, while a drop from 30 to 10 miles per-hour results in a 100% increase in fuel use. Studies estimate that approximately 10% of all on-road fuel consumed is a result of congestion (CEC 1990).

The analysis of transportation energy will focus on the overall energy consumption differences between the system alternatives, which captures the two major transportation fuel inputs, petroleum oil and natural gas (a large component of electricity production). Electricity consumption as a specific item will also be analyzed because of the special nature of electricity, specifically its non-storability and its lack of suitability for trading in futures markets. It is reasonable that the analysis of energy consumption by the HST system is confined to electricity and does not include specific reference to natural gas. The price of natural gas is just one variable in the overall ability of the state's electricity generating infrastructure to deliver adequate power to users. Moreover, it is not the total reserves of in-the-ground natural gas that is uncertain, it is the market conditions and production capacity trends that affect this commodity, just as is the case for the other major transportation fuel, petroleum oil.

### 2.4 EXISTING AND FUTURE NO-PROJECT CONDITIONS

In 1997, the number of intercity passenger trips taken between regions of California that would be served by the proposed HST system was about 154 million (California High-Speed Rail Authority 2000).

Ninety-eight percent of these trips are attributable to automobiles or airplanes with only 2% taken via intercity conventional rail and bus. This corresponds to 14,237 million automobile vehicle miles traveled (VMT) and 62 million airplane VMT.

In 2020 under the No Project/No Action alternative, the number of intercity passenger trips taken in California is projected to be about 215 million (California High-Speed Rail Authority 2000). This corresponds to about 18,866 million automobile VMT and 102 million airplane VMT. The increase in intercity passenger trips is reflective of population growth expected over the same time period, which is estimated by the California Department of Finance to be on the order of 11 million (*California Department of Finance. 1998*).

# 3.0 METHODOLOGY FOR IMPACT EVALUATION

The evaluation of energy supply and demand compares the differences in energy use for intercity travel. This section explains the methodology used to evaluate the potential energy impact/benefit attributable to operations (direct energy) and construction (indirect energy) of the alternatives under study. The evaluation is based on available data and forecasts.

## 3.1 DIRECT ENERGY

Analyses were performed to determine the operational impact to 1) overall state transportation-related energy supply[12] and 2) state electricity supply during period of peak-demand[13].

### 3.1.1 Overall Statewide Energy Supply

Overall direct energy consumption involves potential energy use by the <u>operation of vehicles</u> (automobiles, airplane, and high-speed trains) within the state. Both quantitative and qualitative analyses were used to evaluate the direct impacts to overall energy supply.

The quantitative analysis focused on the direct relationship between vehicle miles-of-travel (VMT) and energy consumption to estimate the change in total energy consumption between the No-Project/No Action Alternative and the Modal and HST Alternatives. The trips considered when modeling VMT were only intercity trips that would be served by the HST system including some and long-distance commute trips. Local commute and other regional and intercity trips were not considered. In the quantitative assessment of direct-energy impacts, consideration was given to the following factors.

- VMT for automobiles, airplanes, and high-speed trains within the study area (this is consistent with the analysis being conducted for air quality in this Chapter).

- Variation of fuel consumption rates by vehicle type.

Projections of HST ridership and the number of trips diverted to HST from other modes, as derived and reported by Charles Rivers Associates in *Independent Ridership and Passenger Revenue Projections for High Speed Rail Alternatives in California* (California High-Speed Rail Authority 2000), were the basis for determining statewide VMT for each mode. Projections in Ridership Report were based on surveys, historical and forecast population, income, and traffic data, airline simulation model, trip durations and departure frequencies, fares, station locations, and amenities. A sensitivity analysis of the Authority's Business Plan investment-grade forecast was performed with variations in mode characteristics that tend to increase HST ridership and revenue to determine how sensitive they are to travel times, fares, etc. This sensitivity analysis produced a high-end ridership forecast that has been used in this Program EIR/EIS to define a maximum impact potential of the system alternatives. This energy analysis applies the high-end CRA sensitivity analysis that includes annual air/auto growth rate of 3.5%/2.0%, 15-minute increase in air travel times at SAN, SFO, and LAX, 30-minute increase in travel time from LA to Bay Area, and 150% increase in airfares. An energy analysis of the Business Plan investment-grade ridership forecast is included for comparison. CRA used 1997 as the base year for their study; this report uses the same year for its existing conditions. Automobile VMT modeling for the HST Alternative were developed as part of this Program EIS/EIR and used to develop VMT values for Existing Conditions and the No-Project and Modal Alternatives.

The VMT fuel consumption method that was used is outlined in the *Technical Guidance*, Section 5309 New Starts Criteria (FTA, Office of Planning 1999). Energy consumption factors for the first two modes

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[12] Overall energy refers to the combination of energy derived from petroleum fuels and electrical energy.

[13] Defined in Section 3.4.1.
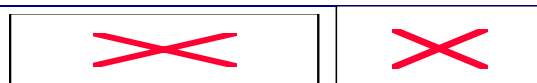
identified in Table 3.1-1 were developed by Oak Ridge Laboratory and published in the 2002 *Transportation Energy Book* (Edition 22) (Oak Ridge Laboratory 2002). These are based on national averages for average road, traffic, and weather conditions and are intended for general comparisons. The energy consumption factor for the HST mode is based on energy used by similarly designed trains, such as the Trains à Grande Vitesse (TGV) in France and the Intercity Express (ICE) in Germany (DE Consult 2003). This report assumes a 16-car trainset with a 1,200-passenger carrying capacity.

**Table 3.1-1**
**Direct Energy Consumption Factors**

| Mode | Factor |
|---|---|
| Passenger Vehicles (auto, van, light truck) [1] | 5,669 Btus/Vehicle Mile Traveled |
| Airplane[1] | 334,086 Btus/Vehicle Mile Traveled |
| High-Speed Trains[2] | 924,384 Btus/Vehicle Mile Traveled |
| Sources: [1]Oak Ridge Laboratory 2002; based on nationally averaged conditions and fleet composition  [2]DE Consult 2000, based on a 16-vehicle trainset. | |

Overall direct energy, measured in Btus, was converted to the equivalent barrels of crude oil to illustrate potential energy impact and/or savings. Annual direct-energy consumption due to intercity travel was calculated for existing, No-Project/No Action, Modal, and HST Alternative scenarios and compared. The change in commuter-derived direct energy consumption from the future 2020 No-Project/No Action condition (in Btus) was calculated for the Modal Alternative and HST Alternative. The qualitative analysis of overall direct energy considers the estimated or assumed levels-of-service for each of the alternatives and the effect that each would have on congestion and travel speeds, which, as noted in Section 3.1.4.1, have a substantial impact on fuel efficiency and, therefore, energy use.

In addition to overall direct energy analysis, calculations of average energy consumption per passenger-mile were calculated for each of the transportation modes essential to the development of the Modal and HST Alternatives.

### 3.1.2 Regional Electricity Supply during Period of Peak-Demand

For the HST Alternative, peak-period electricity demand was determined using an energy consumption factor for high-speed train vehicles, obtained from DE Consult Peer Review Report (DE Consult 2000) and the Operation Plan from the Authority's *Final Business Plan* (2001). The demand was calculated in terms of megawatts and compared to current estimates of peak demand and supply capacity within the Cal-ISO-controlled grid. Peak demand for electricity for the future 2020 No-Project/No Action and Modal Alternatives is discussed qualitatively.

### 3.2 INDIRECT ENERGY

Indirect energy impacts considered here include two different construction-related energy consumption factors: 1) construction of alternatives and 2) secondary facilities.

Construction of Alternatives

Energy consumed as a result of project construction refers to energy used for the actual construction of HST trackway and support facilities or highway expansion or airport runways and transportation of materials and equipment to and from the work site. Estimates of guideway construction energy consumption factors are given for the major facilities related to each of the modes. Values for construction energy consumption factors are given in Table 3.2-1. Construction energy consumption factors for HST systems have not yet been compiled. Instead, data gathered from the experience with typical heavy rail systems and a heavy rail commuter system (Bay Area Rapid Transit [BART]), were used as a surrogate for HST through rural and urban areas, respectively. These estimates should be used as for comparison purposes.

**Table 3.2-1**
**Construction Energy Consumption Factors**

| Mode | Facility | Rural vs. Urban | Factor (billions of Btus) |
|---|---|---|---|
| Automobile[6] | Highway (At-grade) | Rural[1] | 17.07/one-way lane-mile |
| | | Urban[2] | 26.28/one-way lane-mile |
| | Highway (Elevated) | Rural[1] | 130.38/one-way lane-mile |
| | | Urban[2] | 327.31/one-way lane-mile |
| Airplane[7] | Runway | N/A | 6,312/runway |
| | Gate | N/A | 78[3]/gate |
| High-Speed Trains[6,8] | At-Grade | Rural[4] | 12.29/one-way guideway-mile |
| | | Urban[5] | 19.11/one-way guideway-mile |
| | Elevated | Rural[4] | 55.46/one-way guideway-mile |
| | | Urban[5] | 55.63/one-way guideway-mile |
| | Below-Grade (cut) | Rural[4] | 117.07/one-way guideway-mile |
| | | Urban[5] | 163.14/one-way guideway-mile |
| | Below-Grade (tunnel) | Rural[4] | 117.07/one-way guideway-mile |
| | | Urban[5] | 328.33/one-way guideway-mile |
| | Station | N/A | 78[3]/station |

Notes:

[1]Used estimates of average roadway construction energy consumption.

[2]Used estimates of range maximum for roadway construction energy consumption.

[3]Value for construction of freight terminal. Used as proxy for unknown air gate and HST station consumption factors.

[4]Used estimates of typical rail system construction energy consumption.

[5] Used estimates of Bay Area Rapid Transit (BART) system construction energy consumption as surrogate for HST construction through urban area..

Sources:

[6]DeLeuw, Cather and Company in Urban Transportation and Energy: The Potential Savings of Different Modes, The Congress of the United States, Congressional Budget Office (Congressional Budget Office 1977)

[7]Congressional Budget Office in Energy and Transportation Systems, Prepared for the Federal Highway Administration, Sacramento, CA by California State Department of Transportation (Caltrans 1983); based on construction for air freight services.

[8]Fels in Urban Transportation and Energy: The Potential Savings of Different Modes, The Congress of the United States, Congressional Budget Office (Congressional Budget Office 1977)

Construction energy payback period measures the number of years that would be required to pay back the energy used in construction with operational energy consumption savings. It was calculated for this chapter by dividing the estimate of each system alternatives' construction energy by the amount of energy that would be saved by each of the system alternatives vis-à-vis the No-Project Alternative

condition.  It assumes that the amount of energy saved in the study year (2020) would remain constant throughout the payback period.

<u>Secondary Facilities</u>

A secondary facility may be a factory for example, that produces construction materials and machinery that would be used in the construction and maintenance of the alternatives structures and attendant facilities.  Impacts resulting from these two factors are discussed qualitatively.  Consideration was given to whether non-renewable resources are consumed in a wasteful, inefficient, or unnecessary manner with special attention given to the efficiency with which construction materials and machinery are produced and the choices made regarding construction methodology and procedures, including equipment maintenance.

## 3.3 CRITERIA FOR DETERMINING SIGNIFICANCE OF IMPACTS

The goal of conserving energy implies the wise and efficient use of energy.  According to Appendix F of the CEQA Guidelines, the means of achieving this goal include decreasing overall per capita energy consumption, decreasing reliance on natural gas and oil, and increasing reliance on renewable energy sources.
The future 2020 No-Project/No-Action Alternative is the primary basis of comparison.
Significant potential operational energy impacts would occur if the project alternatives would:

- *place a substantial demand on regional energy supply or require significant additional capacity.*

- *significantly increase peak and base period electricity demand.*

Significant potential construction energy impacts would occur if construction of any of the alternatives, would consume nonrenewable energy resources in a wasteful, inefficient, or unnecessary manner. Implementation of the alternatives, would have a significant cumulative adverse effect if it, together with regional growth, would contribute to a collectively significant shortage of regional or statewide energy. By contrast, if the alternatives, resulted in energy savings or alleviated demand on energy resources it would have a beneficial effect.

# 4.0 OPERATIONAL AND CONSTRUCTION IMPACTS

## 4.1 OPERATIONAL (DIRECT) ENERGY IMPACTS

### 4.1.1 No-Project Alternative

#### 4.1.1.1 Statewide and Regional Overall Energy Supply
*Would the alternative place a substantial demand on statewide and/or regional energy supplies or requires significant additional capacity?*

The No-Project Alternative consists of programmed and funded improvements that will be added to the existing state transportation system by 2020. Intercity passenger trips are expected to increase in the period between 1997 (existing conditions) and 2020 from 154 million to 215 million, the former of which generated 14,237 million automobile vehicle-miles traveled (VMT) and 62 million airplane VMT and the latter of which would generate 18.866 million automobile VMT and 102 million airplane VMT. As indicated in Table 4.1-1, the existing (1997) energy used to power intercity passenger trips is 101,525,630 MMBtus, or 17.5 million barrels of oil, whereas the future 2020 No Project/No Action Alternative would consume the equivalent of about 141,023,720 MMBtus, or 24.3 million barrels of oil, which is a 39% increase in energy use over existing conditions. This is a conservative estimate because, as noted in Section 2.3.5, automobile fuel efficiency decreases considerably as travel speed decreases below 30 mph and stop-and-go traffic increases. Since congestion levels in the No-Project Alternative scenario are likely to be higher than they are currently in the Existing Conditions scenario, it is conceivable that the increase in direct energy used in 2020 would be higher than the 39% increase that has been projected without the benefit of traffic-speed data. To illustrate this point, if the direct energy consumption factor for automobiles in a congested No Project/No Action scenario increased by 5%, from 5,669 Btus/VMT to 5,952 Btus/VMT, the total direct energy consumption with the No-Project/No Action Alternative would increase from 141,023,720 million Btus to 146,371,202 million Btus, which represents a 44% increase over existing levels, compared to the 39% increase in direct energy consumption with the assumption of similar levels of service.

Impact Significance Determination

The future 2020 No Project/No Action Alternative would place additional demand on statewide energy supplies compared to existing conditions as a result of increased passenger trips, higher levels of congestion, and slower speeds on intercity highways. *(Potentially significant impact)*

**Table 4.1-1**
**Annual Study Area Intercity Operational Energy Consumption**

| | 1997 | 2020 | | |
| --- | --- | --- | --- | --- |
| | Existing | Future 2020 No Project Alternative7 | Modal Alternative5 | HST Alternative5 |
| **Annual VMT[2,3,] (miles) (millions)** | | | | |
| Auto | 14,237 | 18,866 | 19,073 | 15,816 |
| Airplane[4] | 62 | 102 | 102 | 1 |
| HST | 0 | 0 | 0 | 22 |
| **Annual Energy Consumption (MMBtus)** | | | | |
| Auto | 80,711,153 | 106,949,635 | 108,126,081 | 89,661,289 |
| Airplane | 20,814,476 | 34,074,085 | 34,074,085 | 340,741 |
| HST | 0 | 0 | 0 | 20,304,566 |
| **TOTAL ENERGY CONSUMPTION (MMBtus)** | 101,525,630 | 141,023,720 | 142,200,166 | 110,306,596 |
| **Change In Total Energy From Existing (MMBtus)** | | 39,498,090 | 40,674,536 | 8,780,967 |
| **Change In Total Energy From No-Project (MMBtus)** | | | 1,176,446 | -30,717,124 |
| **TOTAL ENERGY CONSUMPTION (BARRELS OF OIL[6]) (millions)** | 17.5 | 24.3 | 24.5 | 19.1 |
| **Change In Total Energy From Existing (BARRELS OF OIL[6]) (millions)** | | 6.8 | 7.0 | 1.5 |
| **Change In Total Energy From No-Project (BARRELS OF OIL[6]) (millions)** | | | 0.2 | -5.3 |

Notes:
[1] One British thermal unit (Btu) is the quantity of energy necessary to raise 1 pound of water 1 degree Fahrenheit.
[2] VMT based on average number of passengers per vehicle, by mode, as follows:
Intercity auto: 2.4 passengers/automobile
Airplane: 101.25 passengers/airplane (70% load factor)
HST VMT based on Business Plan (CA HSRA 2000)
[3] Intercity travel only; long distance commute travel not included
[4] Does not include airplane VMT resulting from passengers making connections to other flights to continue or complete their journey because these are a minor portion of the HST-served market.
[5] Rounded.
[6] One barrel of crude oil is equal to 5.8 MMBtus.
[7] Fuel consumption for No-Project/No-Action would increase beyond the figures presented here as speeds drop below 30 mph on congested highways.

Sources:
[8] *Charles River Associates 2002; Paul Taylor (Kaku Associates) 2003*

### 4.1.1.2 Peak-Period Electricity Demand
*Would the alternative significantly increase peak-period electricity demand?*

Future 2020 No-Project/ No Action electricity consumption would increase slightly over existing conditions due to programmed and funded No-Project/ No Action airport expansion. The possible future electrification of Caltrain, commuter-rail systems, and/or Amtrak would also increase electricity use. However, these projects, while regionally significant, are smaller in scale by comparison and would be captured by routine electricity consumption forecasts by the CEC, allowing electricity generation and transmission additions planning to account for and accommodate their additions.

Impact Significance Determination

CEC electricity supply capacity and demand projections account for routine expansion of the state's electricity requirements. The No-Project/No-Action Alternative electricity demand would be satisfied by routine expansion and no significant impacts to electricity generating capacity have been identified. *(Less than significant)*

### 4.1.2 Modal Alternative

### 4.1.2.1 Statewide and Regional Overall Energy Supply
*Would the alternative place a substantial demand on statewide and/or regional energy supplies or require significant additional capacity?*

As indicated by the VMT-based, analysis, energy requirements for intercity transportation would be greater under the Modal Alternative than under the No-Project/No Action Alternative because of induced demand for automobile travel related to extra highway capacity. Table 4.1-1 demonstrates that, although the number of airplane VMT would remain the same (it assumed that an increase in the level-of-service for air travel over the No-Project/No Action Alternative would not increase the number of trips because demand would remain the same regardless of which alternative is built), the number of automobile intercity trips taken would increase statewide by 1.1% over the No-Project/No Action Alternative[14], which would increase the number of annual VMT by 208 million to 19,073 million. These additional VMT translate into an additional energy use of 1,176,446 MMBtus, which is the equivalent of 0.2 million barrels of oil. However, as indicated in the Section 2.3.5, automobile fuel efficiency decreases considerably as travel speeds decrease and stop-and-go traffic increases. This means that the higher energy consumption resulting from more VMT would be offset by the Modal Alternative's lower level of congestion in rural highway segments. As an example, if the direct energy consumption factor for automobiles were increased due to congestion by 5% in the No-Project/No Action Alternative, from 5,669 Btus/VMT to 5,952 Btus/VMT, the total energy consumption in the No-Project/No Action scenario would increase from 141,023,720 MMBtus to 146,371,202 Btus. In this scenario, the Modal Alternative would see a 3% decrease in direct energy consumption compared to the No-Project/No Action Alternative.

Impact Significance Determination

The Modal Alternative would have a no impact because it would likely consume about the same, if not slightly less energy than the No-Project/No-Action Alternative because of reduced congestion. (*No impact*)

### 4.1.2.2 Peak-Period Electricity Demand
*Would the alternative significantly increase peak and base period electricity demand?*

Compared to the No-Project/No Action Alternative, there would be some increase in electricity demand in the peak-period under the Modal Alternative due to new/expanded airport facilities. It would be small and be considered in CEC projections of electricity demand and supply capacity.

Impact Significance Determination

The Modal Alternative would impact electricity resources at a less-than-significant level, if the trends continue. *(Less-than-significant impact)*
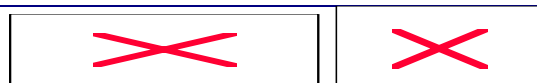
### 4.1.3 High-Speed Train Alternative

### 4.1.3.1 Statewide and Regional Overall Energy Supply
*Would the alternative place a substantial demand on statewide or regional energy supplies or require significant additional capacity?*

Statewide

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[14] Trips that would be induced, also called latent demand, as a result of the improved level-of-service

As indicated by the VMT-based analysis, energy requirements for intercity transportation would be reduced under the HST Alternative compared to the No-Project/No Action Alternative. Table 4.1-1 demonstrates that the HST Alternative would decrease intercity automobile VMT from 18,865 million under the No-Project/No Action Alternative scenario to 15,816 million, decrease airplane VMT from 102 million to 1 million, assuming high-end ridership forecasts, and increase HST VMT attributable to intercity trips from 0 to 22 million. Commuter automobile VMT (based on 1.0 passengers per automobile) would also decrease by 509 million compared to No-Project/No Action and HST VMT attributable to commuter trips would increase from 0 to 2 million. Where the HST system would use 20,304,566 MMBtus for trips related to intercity travel, the overall direct energy for intercity travel would be 30,717,124 MMBtus, or the equivalent of 5.3 million barrels of oil, less per year than the No-Project/No Action Alternative. This reduction represents a 22% energy savings for intercity trips over the No-Project/No Action Alternative and a 9% increase over Existing Conditions (1997) direct energy consumption. HST operations related to commuter travel would use 1,630,199 MMBtus. However, the 10 million commute-related passenger trips diverted from automobiles to HST would result in a decrease in energy use by automobiles of 2,886,699 MMBtus. This would result in a net reduction in commute-related direct energy consumption of 1,256,500 MMBtus, compared to the No-Project/No Action Alternative.

The VMT-based energy calculations above do not account for congestion levels. As congestion levels decrease, so does energy use for transportation. It is likely, therefore, that the projected 22% energy consumption reduction with the HST Alternative is conservative, since intercity route congestion levels are expected to lessen in rural areas as a result of its implementation. Using the example of a 5% increase in the energy consumption factor for automobiles due to congestion, explained above under Modal Alternative, a congested No-Project/No Action Alternative could hypothetically see a direct-energy consumption of 146,371,202 MMBtus, compared to the 141,023,720 MMBtus anticipated in a less-congested No-Project/No Action scenario. This scenario would result in additional intercity direct-energy savings with the HST Alternative of about 5,347,482 MMBtus, which represents a 17% increase in the amount of energy saved. Thus, the total energy savings with the HST alternative and High-End ridership could be as great as 25% over No-Project/No Action Alternative.

An energy intensity analysis of the alternatives was also calculated using passenger miles traveled (PMT) for each of the modes. This is a useful value for anticipating how each of the alternatives would affect energy use. Table 4.1-2 lists the energy intensity of each of the modes. HST service offers a sharp reduction in energy consumption per passenger mile compared to other modes.

**Table 4.1-2**
**Energy Consumption Factors (based on PMT)**

| Mode | Energy Consumption[5] |
|---|---|
| Intercity Passenger Vehicles (auto, van, light truck) [1] | 2,400 Btus/Passenger Mile-of-Travel |
| Commute Passenger Vehicles (auto, van, light truck) [2] | 5,700 Btus/Passenger Mile-of-Travel |
| Airplane[3] | 3,300 Btus/Passenger Mile-of-Travel |
| High-Speed Trains[4] | 1,200 Btus/Passenger Mile-of-Travel |
| Notes:<br>[1]Based on 2.4 passengers per vehicle.<br>[2]Based on 1.0 passengers per vehicle.<br>[3]Based on 101.25 passengers per vehicle (70% load factor).<br>[4]Based on 761 passengers per 16-car trainset (63% load factor, which would accommodate the projected 2020 high-end demand for HST service within the existing Operations Plan).<br>[5]Rounded. | |

Regional
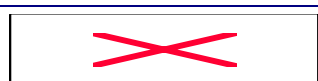
In addition to the statewide direct automobile VMT savings resulting from travelers choosing high-speed train travel, the HST Alternative would provide additional regional VMT reductions, compared to No-Project conditions. HST station-stops would be more numerous than airports in all of the corridor regions, which would result in a lessening of the average distances required for passengers to travel from their points-of-origin to the mode transfer point (and vise versa) because of the likelihood that one or more of the stations would be closer to their point-of-origin than would their respective regional airport.

Implementation of the HST Alternative would also decrease regional transportation-related energy consumption through proposed improvements to rail corridors in the Bay Area to Merced and LOSSAN Regions. Grade separations are planned for Caltrain and the LOSSAN corridor as part of the proposed HST project, which would increase traffic flow in the affected areas, thereby increasing fuel efficiency and decreasing energy consumption.

Impact Significance Determination

The analysis shows that the HST Alternative would have a beneficial impact statewide, as it would consume far less energy than either the No-Project/No Action or Modal Alternatives as a result of reducing combined VMT. When compared to the Modal Alternative, the HST Alternative would save 31,893,570 MMBtus, or about 5.5 million barrels of oil, every year, which equates to an approximate 22% savings. Regional analysis indicates that that regional efficiencies precipitated by the HST Alternative would improve on these projected savings. *(Beneficial impact)*

Investment Grade Ridership Forecast

Based solely on VMT, the HST Alternative with the assumption of the investment grade ridership forecast would reduce overall direct energy use for intercity travel 2020 by 11,749,680 MMBtus, or the equivalent of 2.0 million barrels of oil compared with the No-Project/No Action Alternative. This reduction represents an 8% energy savings for intercity trips over the No-Project/No Action Alternative and a 27% increase over Existing Conditions (1997) direct energy consumption. This compares to 22% reduction over the No-Project/No Action Alternative and 9% increase over existing conditions (1997) with the high-end sensitivity analysis ridership forecast. Using the example of a 5% increase in the energy consumption factor for automobiles in congested No-Project/No Action Alternative conditions, intercity direct energy savings with the HST Alternative would be 17,097,162 MMBtus with the assumption of investment grade ridership projections compared to the 36,064,605 million-Btu savings with the high-end ridership forecast. Commuter diversion to HST would not change with the investment grade forecast. Table 4.1-3 shows the operational energy consumption for the System Alternatives using the investment grade ridership forecast. Estimates for No-Build and Modal System Alternatives do not change since HST ridership would not affect them.

Table 4.1-3

**Annual Study Area Intercity Operational Energy Consumption Assuming Investment-Grade Ridership Forecasts**

| | 1997 | 2020 | | |
| --- | --- | --- | --- | --- |
| | Existing | Future 2020 No Project Alternative7 | Modal Alternative5 | HST Alternative5 |
| **Annual VMT[2,3,8] (miles) (millions)** | | | | |
| Auto | 14,237 | 18,866 | 19,073 | 17,367 |
| Airplane[4] | 62 | 102 | 102 | 41 |
| HST | 0 | 0 | 0 | 22 |
| **Annual Energy Consumption (MMBtus)** | | | | |
| Auto | 80,711,153 | 106,949,635 | 108,126,081 | 98,458,799 |
| Airplane | 20,814,476 | 34,074,085 | 34,074,085 | 13,556,367 |
| HST | 0 | 0 | 0 | 17,258,873 |
| **TOTAL ENERGY CONSUMPTION (MMBtus)** | 101,525,630 | 141,023,720 | 142,200,166 | 129,274,040 |
| **Change In Total Energy From Existing (MMBtus)** | | 39,498,090 | 40,674,536 | 27,748,410 |
| **Change In Total Energy From No-Project (MMBtus)** | | | 1,176,446 | -11,749,680 |
| **TOTAL ENERGY CONSUMPTION (BARRELS OF OIL[6]) (millions)** | 17.5 | 24.3 | 24.5 | 22.3 |
| **Change In Total Energy From Existing (BARRELS OF OIL[6]) (millions)** | | 6.8 | 7.0 | 4.8 |
| **Change In Total Energy From No-Project (BARRELS OF OIL[6]) (millions)** | | | 0.2 | -2.0 |

Notes:

[1] One British thermal unit (Btu) is the quantity of energy necessary to raise 1 pound of water 1 degree Fahrenheit.

[2] VMT based on average number of passengers per vehicle, by mode, as follows:
   Intercity auto: 2.4 passengers/automobile
   Airplane: 101.25 passengers/airplane (70% load factor)
HST VMT based on Business Plan (CA HSRA 2000)

[3] Intercity travel only; long distance commute travel not included

[4] Does not include airplane VMT resulting from passengers making connections to other flights to continue or complete their journey because they are a minor portion of the HST-served market.

[5] Rounded.

[6] One barrel of crude oil is equal to 5.8 MMBtus.

[7] Fuel consumption for No-Project/No-Action would increase beyond the figures presented here as speeds drop below 30 mph on congested highways.

Sources:

[8] Charles River Associates 2002; Paul Taylor (Kaku Associates) 2003

With the investment grade HST ridership projections, the energy consumption per passenger-mile traveled on the high-speed train would be about 1,800 Btus per passenger-mile traveled compared to about 1,200 Btus per passenger mile traveled when the high-end ridership forecast is assumed.

Regional energy savings with investment grade ridership projections would not be qualitatively different than those expected with the sensitivity analysis variations in the ridership forecast.

### 4.1.3.2 Peak-Period Electricity Demand
*Would the alternative significantly increase peak and base period electricity demand?*
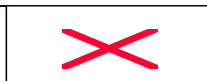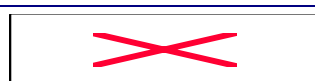
Electrical power demanded by and HST system would increase the load on the statewide system on the order of 480 MW[15] during the period of peak electricity demand in 2020. Electricity supply and demand projections are not available for 2020 because such a long time horizon has uncertainty, especially on the supply-side, where capacity additions are difficult to predict more than 2 to 3 years into the future. However, it is useful to compare the expected high-speed train-related operational electricity demand to surplus projections through 2008, the year that is farthest into the future for which electricity production capacity projections are available. CEC estimates that statewide electricity surplus generating capacity[16] in 2008 will be 5,210 MW, based on a total generating capacity of 64,669 MW and a demand of 59,459 MW (CEC 2003c). If the system were to become operational in 2008, the additional load placed on the system by the HST Alternative would be about 10% of the state's anticipated electricity surplus. Prediction horizons for demand estimates are longer than for capacity additions. Comparing the additional 480-megawatt load placed on statewide electricity generating resources by the HST Alternative would represent approximately 0.7% of the CEC-predicted 2012 statewide electricity demand of 64,845 MW. Projecting the demand horizon to the study year of 2020, the HST Alternative-generated load would represent 0.6% of an estimated 77,000 MW statewide demand[17].

The demand growth extrapolation based on CEC demand predictions assumes an average annual electricity demand growth on the order of 1,400 MW through 2020, about three times the 480-megawatt load that the HST operations are expected to place on the statewide system. The HST Alternative would be built and become operational in stages, which indicates that, instead of placing a 480-MW load on the state's production and transmission resources abruptly, the system would gradually increase its electricity consumption rate to 480 MW. This would allow the domestic and out-of-state electricity generation and transmission industries and planners to anticipate and respond to the effects of the HST Alternative on generating and transmitting resources.

Regional

Regional impacts to the electricity grid could occur if the HST Alternative would contribute to electricity transmission deficiencies, or bottlenecks, which were described in Section 2.3.4. If bottlenecks were to be aggravated by the HST Alternative, a potentially significant impact would be incurred. However, through careful HST electrification design, it would be possible to minimize or eliminate such potential problems. Also, bottlenecks in the current grid system are being addressed by such projects as the Path 15 upgrade (see Section 2.3.4). If planning transmission line capacity continues to anticipate statewide needs, the HST would not have the potential to cause a significant impact to transmission. The Modal Alternative is not expected to cause substantial electricity demand increases in any of the regions.

Impact Significance Determination

The HST Alternative would cause potentially significant impacts to the peak-demand on the state's electricity grid if the resource capacity were not equipped to handle the additional load. However, the short-term electricity generation outlook is favorable and the medium- to long-term demand scenarios indicate that the HST Alternative would represent a very small portion of statewide demand. If current trends continue, electricity generation and transmission capacity would satisfy the underlying growth in demand, estimated to average about 2% per year. The HST Alternative would represent a small percentage of the generating and transmission capacity required to satisfy projected demand. Staging of the completion of construction and the start of major operations would make the load additions by each

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[15] Based on an average electricity use of 74.2 kW/train mile, which equates to an average electricity use rate of the order of 12 MW per trainset when integrated over one hour. These are averages and do not reflect acceleration or changes in grade; they are for planning purposes only.

[16] Assuming a normal summer and including existing generation, retirements, high probability California additions, net firm imports, and spot market imports.

[17] Calculation based on CEC demand projections from 2002 to 2012 for normal temperature years, published in *2002 – 2012 Electricity Outllook* (CEC 2002b). Projection to 2020 assumes an average annual growth rate of about 2.0% with a range from between 1.5% and 3.9%. This projection is for comparison purposes only.
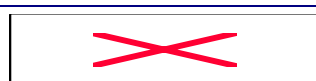
of the System Alternatives less abrupt than would be the case if all the construction and the start of the full planned operational cohort were to occur simultaneously. *(Less-than-significant impact).*

Investment Grade Ridership Forecast

Whereas the high-speed train would consume electricity at the rate of the order of 480MW with the sensitivity analysis variations in the ridership forecast, which would generally require 16-car trainsets to accommodate the expected passenger demand, the system would consume electricity at the reduced rate of the order of 410MW[18] with the investment grade ridership forecast, which would generally require 12-car trainsets to accommodate passenger demand.

## 4.2 CONSTRUCTION (INDIRECT) ENERGY IMPACTS

### 4.2.1 No-Project Alternative

*Would the construction of the alternative consume nonrenewable energy resources in a wasteful, inefficient, or unnecessary manner?*

The No-Project/No Action Alternative is based on the assumption that others would complete projects (both public works and private development), including local, state, and interstate transportation system improvements, designated in existing plans and programs.  It is assumed that construction of the projects included in the No-Project/No Action Alternative would not result in the consumption of energy resources in a wasteful, inefficient, or unnecessary manner.

Impact Significance Determination

Construction of the No-Project Alternative would be guided by the mitigation measures identified in specific environmental documents for the planned and funded No-Project projects. *(No impact)*

### 4.2.2 Modal Alternative

*Would the construction of the alternative consume nonrenewable energy resources in a wasteful, inefficient, or unnecessary manner?*

Project Construction

The Modal Alternative construction-related energy consumption would result in the one-time, non-recoverable energy costs associated with construction of new/expanded airport runways, airport facilities, roadways (an estimated 2,970 lane-miles statewide), interchanges, ramps and other support facilities (rest areas, maintenance facilities). Details regarding energy conservation practices have not been specified for the Modal, since it has not been designed to any detail and construction methods and staging have not been identified.  Given the scope and scale of the improvements proposed as part of the Modal Alternative, however, it is anticipated that the construction-related energy requirement would be substantial.   Table 4.1-4 shows estimates of construction-related indirect energy consumption for the Modal Alternative.   The Modal Alternative would consume about 230,550,000 MMBtus during construction, or 51% more than the HST Alternative.

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[18] Based on an average electricity use of 63.07 kW/train mile, which equates to an average electricity use rate of the order of 10 MW per trainset when integrated over one hour.  The rate of electricity use by a 12-car trainset was assumed to be 85% of the rate used by a 16-car trainset.  These are averages and do not reflect acceleration or changes in grade; they are for planning purposes only.
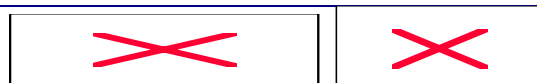
**Table 4.1-4**

**Non-Recoverable Construction-Related Energy Consumption**

| Alternative | Structure | Rural vs. Urban[1] | Facility Quantity[2] | Energy Consumption[3] (MMBtus) |
|---|---|---|---|---|
| **Modal** | *Highway (At-Grade)* | Rural | 1,476 one-way lane miles[4] | 25,187,000 |
| | | Urban | 795 one-way lane miles[4] | 20,879,000 |
| | *Highway (Elevated)* | Rural | 455 one-way lane miles[4] | 59,323,000 |
| | | Urban | 245 one-way lane miles[4] | 80,191,000 |
| | *Subtotal* | | | 185,580,000 |
| | *Airport (Runway)* | N/A | 6 runways | 37,872,000 |
| | *Airport (Gates)* | N/A | 91 gates | 7,098,000 |
| | *Subtotal* | | | 44,970,000 |
| | ***Modal Alternative Total*** | | | **230,550,000** |
| **HST** | *HST Guideway (At-Grade)* | Rural | 2,263 guideway-miles | 27,807,000 |
| | | Urban | 640 | 12,224,000 |
| | *HST Guideway (Elevated)* | Rural | 333 guideway-miles | 18,442,000 |
| | | Urban | 161 | 8,972,000 |
| | *HST Guideway (Below-Grade, Cut)* | Rural | 19 guideway-miles | 2,239,000 |
| | | Urban | 30 | 4,868,000 |
| | *HST Guideway (Below-Grade, Tunnel)* | Rural | 242 guideway-miles | 28,322,000 |
| | | Urban | 146 | 47,958,000 |
| | *HST Station* | N/A | 20 stations | 1,560,000 |
| | ***HST Alternative Total*** | | | **152,390,000** |

[1]Assumes the HST and Modal System Alternatives would be constructed in rural and urban areas at the following proportions:

Bay Area – Merced: Rural (70%); Urban (30%)

Sacramento – Bakersfield: Rural (95%); Urban (5%)

Bakersfield – Los Angeles: Rural (70%); Urban (30%)

Los Angeles – Orange – San Diego: Rural (30%); Urban (70%)

Los Angeles – Inland Empire – San Diego: Rural (60%); Urban (40%)

[2]Measured in Guideway Miles for non-discrete structures, i.e., highways and HST guideways, and in structure quantities for discrete structures, i.e., airport runways and terminals and HST stations.

[3]Rounded.

[4]Based on 2,970 miles of highway lane additions; distribution between at-grade (65%) and elevated (35%) estimated for comparison purposes—true values are not known at current level of planning.

Assuming that the 2020 energy savings for each of the system alternatives remain constant and an un-congested No-Project scenario, the Modal System Alternative would not repay the construction energy estimated to be consumed as a result of its implementation because more operational energy would be consumed by the Modal System Alternative than by the No-Project Alternative. With an assumed 5% increase in No-Project automobile operational energy, the Modal System Alternative would consume less energy than this assumed congested No-Project Alternative and would render a construction energy payback period of 55 years.

Secondary Facilities

It is assumed that secondary facilities, such as used in the production of cement, steel, etc., employ all reasonable energy conservation practices in the interest of minimizing the cost of doing business. In fact, industry in California reduced electricity usage (which is mostly generated by natural gas, a non-renewable fuel) from 54.7 million MWh in 2000 to 52.2 million MWh in 2001, a 4.6% reduction, even as the state's population increased by 513,352, or 1.5% (CEC 2002d). As such, it can be assumed that Modal Alternative construction-related energy consumption by secondary facilities would not consume non-renewable energy resources in a wasteful, inefficient, or unnecessary manner.

Construction of the Modal System Alternative is anticipated to take about 10 years beginning in 2005 and finishing in 2016. Construction would occur in stages with segments open for operation while others are still under construction. Given the scope and scale of the improvements proposed as part of the Modal System Alternative, it is anticipated the construction-related energy requirement would be substantial.

Impact Significance Determination

The scope and scale of the improvements proposed in the aviation and roadway components of the Modal Alternative would potentially present a significant use of non-renewable resources. *(Potentially significant impact)*

Investment Grade Ridership Forecast

The HST System Alternative would have a payback period of 12 years with the investment grade ridership projections compared to 5 years with the sensitivity analysis variations in the ridership forecast. Assuming a 5% increase in the No-Project/No-Action Alternative automobile energy consumption due to congestion, the HST System Alternative would have a payback period of 9 years with the investment grade ridership projections compared to 4 years with the sensitivity analysis variations in the ridership forecast.

## 4.2.3 High-Speed Train Alternative

*Would the construction of the alternative consume nonrenewable energy resources in a wasteful, inefficient, or unnecessary manner?*

Project Construction

The HST Alternative construction-related energy consumption would result in a one-time, non-recoverable energy cost, which would occur during demolition, tunneling, and construction of on-the-ground facilities such as trackwork, guideways, structures, maintenance yards, stations, and support facilities. Details regarding energy conservation practices have not been specified for the HST Alternative, since it has not been designed to any detail and construction methods and staging have not been identified. Given the scope and scale of the improvements proposed as part of the HST Alternative, however, it is anticipated that the construction-related energy requirement would be substantial. Table 4.1-4 shows estimates of construction-related indirect energy consumption for both of the Modal and HST Alternatives

As illustrated, the construction of the HST Alternative would consume 34% less energy during construction than the Modal Alternative. The HST System Alternative would payback the construction energy consumption in 5 years with an un-congested No-Project scenario and would render a 4-year payback period if a 5% automobile congestion energy consumption penalty were assumed.

Secondary Facilities

As is the case with the Modal Alternative, it is assumed that secondary facilities, such as used in the production of materials, would employ all reasonable energy conservation practices in the interest of minimizing the cost of doing business.

Impact Significance Determination

Due to the scope and scale of the improvements proposed as part of the HST Alternatives, construction-related energy impacts would be potentially significant. Though the construction energy consumption factors presented in Table 4.1-4 indicate that the HST Alternative would consume less energy during construction than the Modal Alternative, how much less is not known as a result of limited data availability. The HST System Alternative would potentially present a significant use of non-renewable resources compared to the No-Build Alternative. *(Potentially significant impact)*

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